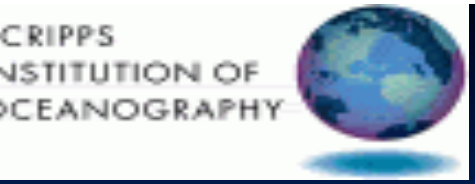


Ensemble Kalman Filtering in the MITgcm with DART

- SIO: Ibrahim Hoteit
  Bruce Cornuelle
- NCAR: Jeffrey Anderson
  Tim Hoar
  Nancy Collins

MIT, Sep 22, 2008

Regional MITgcm Assimilation at SIO

- Tropical Pacific 1/3 degree and 1/6 degree
- CalCOFI 1/10 degree
- Gulf of Mexico 1/10 degree
- San Diego region 1 km
- Taiwan region (to come)

→ All with ECCO-adjoint assimilation

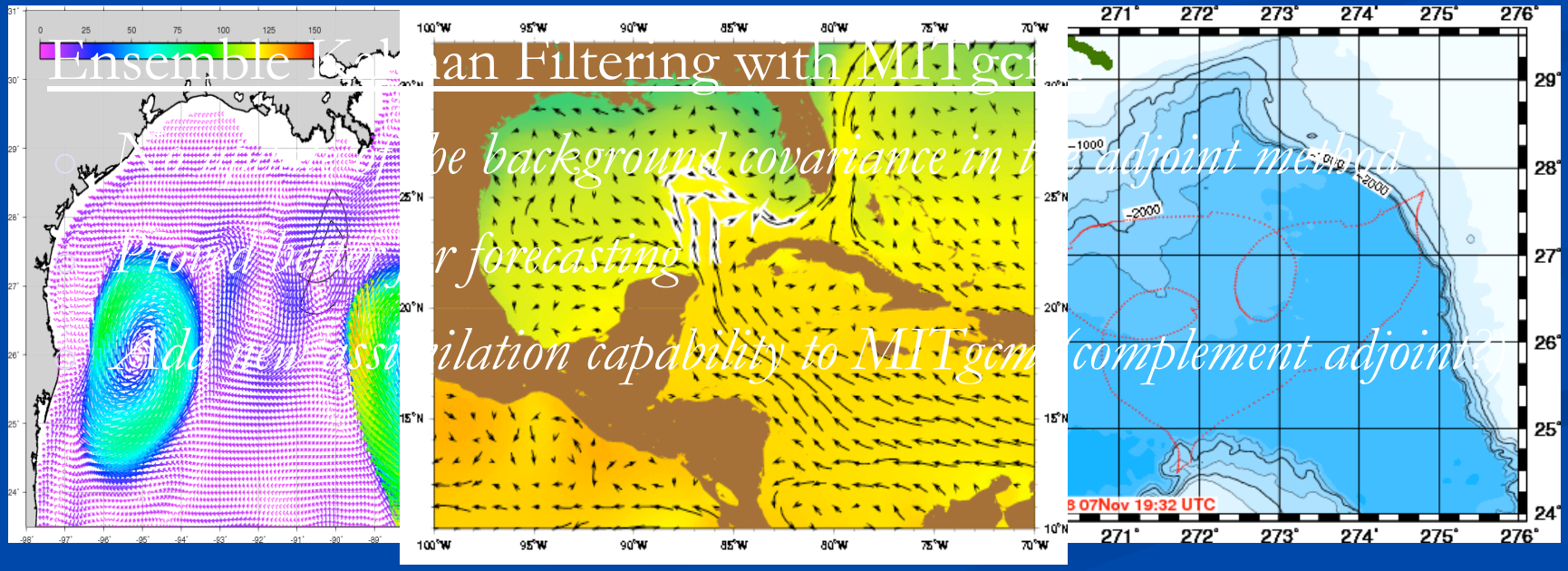
… Ensemble Kalman Filtering

Outline

- What For?
- Ensemble Kalman Filtering
- Pros & Cons
- Data Assimilation Research Testbed -- DART
- DART implementation with MITgcm
- An Example of Fit

What For?

- The BP – Scripps GOM project:
  - *Predict the front of the loop current in the Gulf of Mexico*
  - *Deploy gliders and HF radars and use data assimilation*
  - *1/10º Gulf of Mexico MITgcm forced by ECCO*
- Ensemble Kalman Filtering with MITgcm
  - *Model the background covariance in the adjoint method*
  - *Provide a better error forecasting*
  - *Add new assimilation capability to MITgcm (complement adjoint?)*



Ensemble Kalman Filtering (EnKF)

Ensemble Kalman Filter

Forecast Step

- Integrate analysis

Integrate ensemble with Model

P = Cov(ensemble)

$$P_k^f = M_{k,k-1} P_{k-1} M_{k,k-1}^T + Q_k$$

Analysis Step

- Correct forecast

$$x_k^a = x_k^f + G_k[y_k - H_k x_k^f]$$

- Update error covariance

$$P_k^a = P_k^f - G_k H_k^f P_k^f$$

- Kalman Gain

$$G_k = P_k^f H_k^T [H_k P_k^f H_k^T + R_k]^{-1}$$

- EnKFs: *Represent uncertainties about the state estimate by an ensemble of points*

Pros & Cons

- Easily portable
- Provide estimates of the background covariance matrix
- Offers more flexibility
  → from an OI to Ensemble Kalman filters
- Rank deficient → *Localization and Inflation are needed!*

Data Assimilation Research Testbed --DART

- A software facility employing different EnKFs
- DART is designed so that incorporating new models and observations requires minimal coding of a small set of interface routines
- Advanced localization/inflation schemes
- Operationally used with CAM and WRF at NCAR, MA2 at GFDL, and elsewhere …

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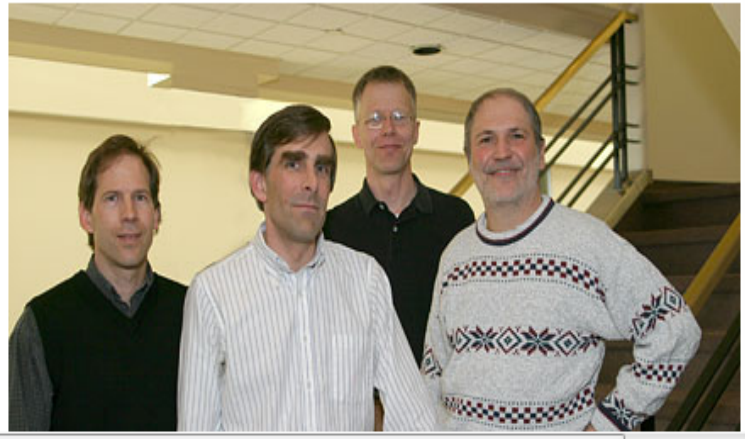
Initiatives in Brief: Data Assimilation Initiative (DAI)

In this series, the UCAR Quarterly profiles one or more of the NCAR strategic initiatives each issue. General background on the initiatives.



Done

Data Assimilation Research Testbed -- DART - Mozilla Firefox

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http://www.image.ucar.edu/DAReS/DART

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$$p(x, t_k \mid Y_{t_k}) = \frac{p(y_k \mid x_k)\, p(x, t_k \mid Y_{t_{k-1}})}{\int p(y_k \mid \xi)\, p(\xi, t_k \mid Y_{t_{k-1}})\, d\xi}$$

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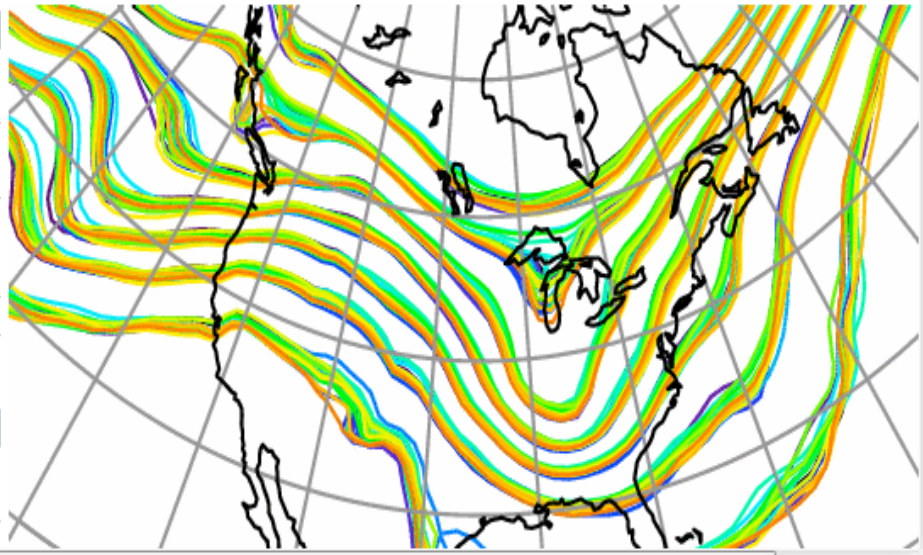
The Data Assimilation Research Testbed -- DART



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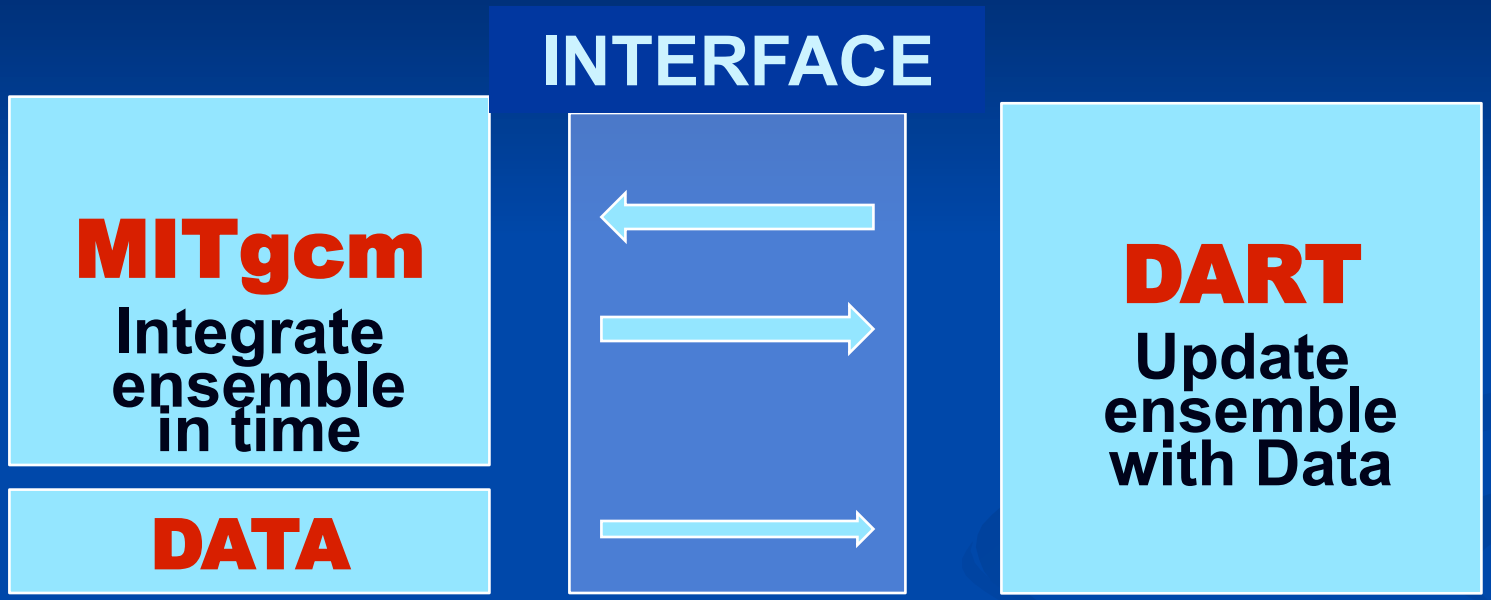
DART Implementation with MITgcm

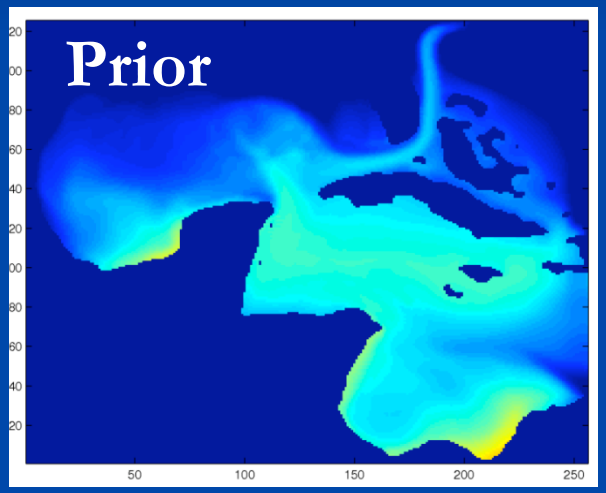


- No modification to the MITgcm
- Scaling of DART parallel algorithm is independent of model
- Enabled for assimilation of most ocean data sets

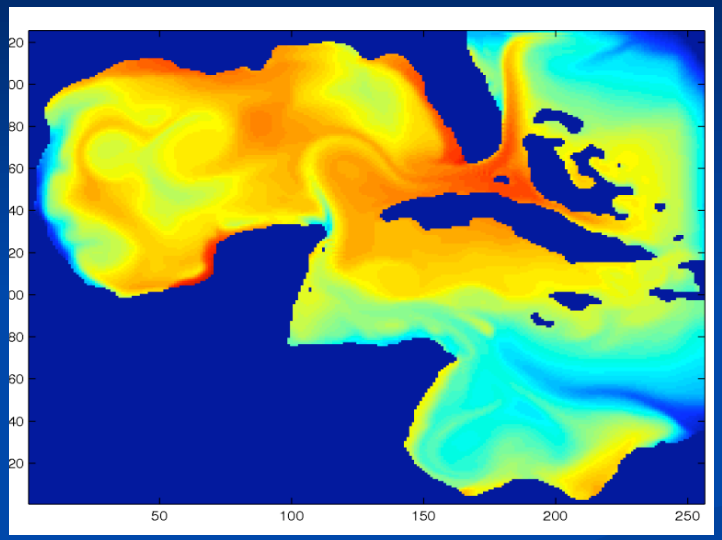
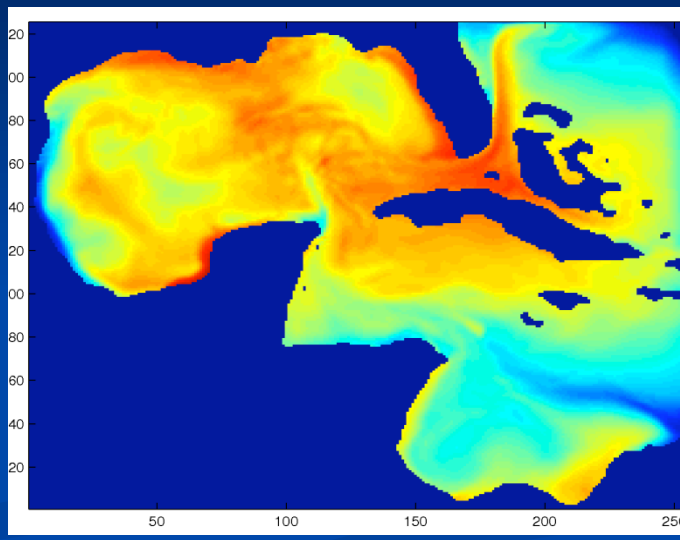
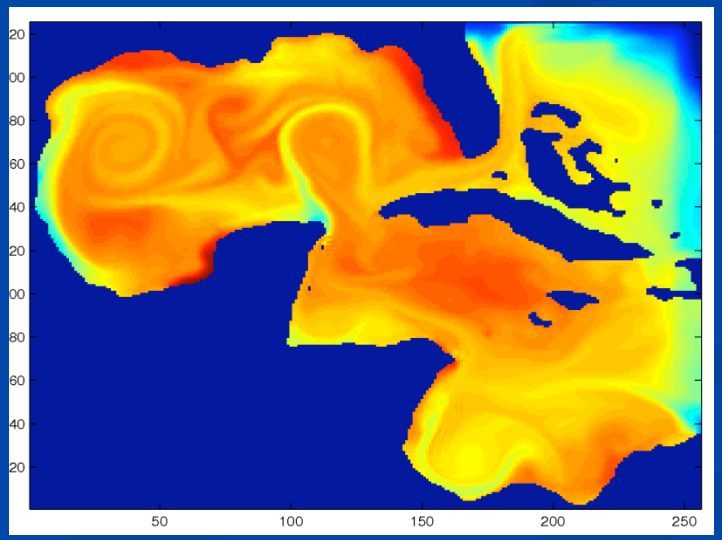
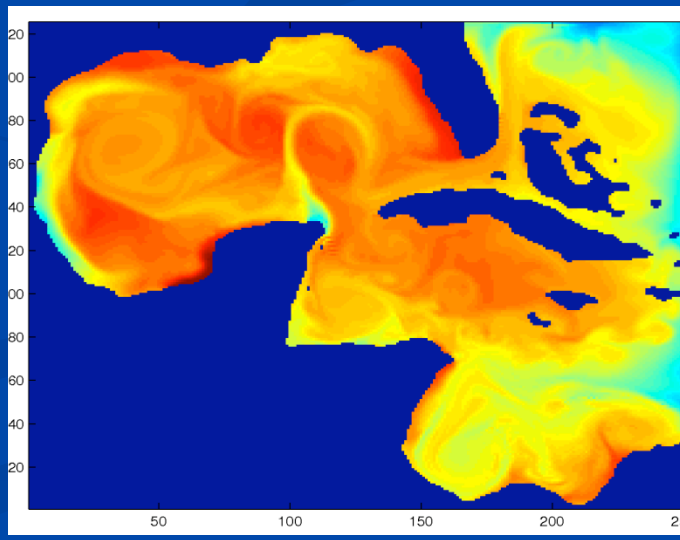
An Example of Fit

30 members

July 1st, 1996



12 weeks later

Pseudo-DATA	Posterior
	
	

To conclude

- The machinery is now working
- Early testing shows good fit
- ... Will be tested with real data

➢ Thank you